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CAUSES AND EFFECTS OF FATIGUE IN EXPERIENCED MILITARY AIRCREW

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PREFACE

This report covers the period of 15 October 2004 to 15 December 2004. The work was performed by Mary L. Melfi in partial fulfillment of the requirements of the degree of Master of Aeronautical Science, Embry-Riddle Aeronautical University, Extended Campus, San Antonio Resident Center, December 2004.

Both of the authors of this report are aircrew-scientists. Prior to undertaking her Masters studies, the principal investigator, Ms. Melfi, served as a USAF F-15E Strike Eagle Weapon Systems Officer in Operation Iraqi Freedom. She logged 250 hours of combat time and was awarded the Distinguished Flying Cross twice, once for heroism, and the Air Medal with three Oak Leaf Clusters.

Dr. James C. Miller served as a co-investigator on the project and as editor of this technical report. Prior to undertaking his doctoral studies, Dr. Miller served as a USAF C-130E Hercules tactical transport pilot in Viet Nam. He logged 699 hours of combat time and was awarded the Distinguished Flying Cross and the Air Medal with four Oak Leaf Clusters.

SUMMARY

The purpose of this investigation was to determine how aircrews perceived fatigue countermeasures, whether they had been fatigued in flight, what might have caused fatigue in the cockpit, and whether they would have benefited from medication during crew rest and while to counteract the effects of fatigue. Data were collected with a self-report survey, eliciting responses from 162 pilots and navigators with experience in fighter, airlift, tanker, helicopter and bomber aircraft types. A high proportion of the respondents had logged more than 3,000 military flight hours. The patterns of responses indicated that:

- Episodes of unintentional sleep may be common in cockpits throughout the USAF.
- Episodes of fatigue-induced performance degradation may be common in cockpits throughout the USAF.
- Degraded situational awareness and slowed reaction time due to fatigue had been experienced while flying.
- Disruption of the circadian rhythm was the greatest contributor to losing sleep and becoming fatigued.
- Improper mission scheduling may be the main cause for in-flight fatigue.
- Poor sleeping quarters contribute to in-flight fatigue.
- The aircrews had received sufficient training and education on the different countermeasures that combat fatigue, but still reported personal experiences of fatigue in the cockpit.
- There were overall biases against the use of Go and No-Go pills, but biases in favor of using them among those who had actually used them as fatigue countermeasures for missions.

INTRODUCTION

Fatigue has been a problem documented in the aviation community since Lindbergh's solo flight across the Atlantic in 1927 (Berg, 1998; Lindbergh, 1953; National Geographic Home Video, 2001). More recent examples include the DC-8 crash of August 1993 at Guantanamo Bay, Cuba, attributed to crew fatigue (NTSB, 1994); and the 2:00 am crash in August 1997 of Korean Air Flight 801 into high terrain southwest of Won Guam International Airport, Guam, attributed in part to the captain's fatigue (NTSB, 2000).

Personal combat flight experience and reports of fatigue-related aircraft mishaps (Melfi, 2005) suggested that U.S. Air Force aircrews perceived that they did not have enough education about fatigue countermeasures, that they had been fatigued in flight, that poor scheduling was a direct contributor to their fatigue in the cockpit, and that they would have benefited from medication during crew rest and while airborne to counteract the effects of fatigue. Thus, the following specific hypotheses were tested through survey questions presented to aircrew with two or more years of operational experience and assigned to the 12th Flying Training Wing (FTW), Randolph AFB, Texas:

- h₁. Experienced at least one episode of unintentional sleep while flying in their crew position on their aircraft.
- h₂. Experienced at least one performance degrading effect of fatigue while flying in their crew position on their aircraft.
- h₃. Perceive that improper scheduling is the main cause for their in-flight fatigue.
- h₄. Have not received sufficient training and education on the different countermeasures that combat fatigue.
- h₅. Would benefit from medication ("Go Pills") – stimulants to aid in wakefulness during flight to help combat the effects of fatigue during an operational mission.
- h₆. Would benefit from medication ("No-Go Pills") – sleeping pills to assist them in adjusting their circadian rhythm, to help combat the effects of fatigue.
- h₇. The quality of sleeping quarters contributed to incidents of in-flight fatigue.

METHODS

RESEARCH DESIGN

The investigation was descriptive (Gay and Airasian, 2003). Data were collected with a self-report survey. We examined seven hypotheses concerning aircrew fatigue in flight operations. Aircrews were surveyed on their opinions of flight scheduling and crew rest requirements in flight operations and their perceptions of the education they had received on fatigue countermeasures.

POPULATION

For the purposes of this investigation, the research population was defined as USAF active duty pilots and navigators. All pilots in the USAF were commissioned officers. To become an officer in the USAF, they had first have completed a Baccalaureate degree in any subject from an accredited college or university with a minimum 2.0 grade point average. All received their officer's commission from the United States Air Force Academy, Air Force Reserve Officer Training Corps, or Officer Training School.

To attend pilot and navigator training, all applicants had to begin flight school prior to their 30th birthday. All of the pilots had completed Joint Specialized Undergraduate Pilot Training (JSUPT). All navigators in the USAF were commissioned officers who had completed Joint Specialized Undergraduate Navigator Training (JSUNT).

After receiving their wings, rated pilots and navigators could be assigned to fly a variety of major weapon systems within the USAF inventory including fighter, bomber, tanker, airlift, or command, control and reconnaissance (C2ISR) aircraft. They were assigned to their aircraft type approximately six weeks prior to graduation. They attended a Replacement Training Unit (RTU) to learn the preliminaries of how to fly and perform the mission of their assigned aircraft. The duration of the RTU varied from one aircraft type to another but lasted approximately three to eight months.

Once finished with RTU, the aircrews were assigned to the base from which they would fly for their first two and a half- to four-year assignment. Upon arrival at this base, the aircrew began Mission Qualification (MQ) upgrade. The MQ upgrade was designed to prepare the aircrew to fly their aircraft mission proficiently enough to become Mission Ready (MR), also known as combat ready or operational. This upgrade began approximately two weeks after arriving at the aircrew member's operational base. It took as little as two weeks in the airlift community to as long as four months in the fighter community. Upon completion of the aircrew member's first assignment they had most likely been operational for at least two years. Once MR, the aircrews were prepared to employ their aircraft operationally to fulfill the mission of the Air Force.

The pilots who were assigned to a Trainer aircraft after pilot training attended a similar course. They attended Pilot Instructor Training (PIT) at Randolph AFB, San Antonio, Texas. They then returned as instructor pilots to a JSUPT base to teach new students how to become pilots. PIT lasted for approximately five months. These pilots were

known as First Assignment Instructor Pilots (FAIPs) and did not develop operational experience during their first assignment.

The research sample was drawn from the population of interest and all members of this sample were assigned to the 12th Flying Training Wing, Randolph AFB, Texas. They were flying the T-1, T-6, T-37, T-38 or T-43 trainer aircraft. FAIPs were not included in the research sample since they did not have any operational experience. The remaining aircrew members had previous operational experience flying fighters, bombers, airlift, tankers, or flying command, control, intelligence, surveillance and reconnaissance (C2ISR).

SURVEY INSTRUMENT

As no standardized research instrument could be located to test the stated hypotheses, a self-report questionnaire was created (Appendix). There were 17 questions on the survey; seven questions were used to test the hypotheses, while 10 questions provided demographic and supplemental information. The response options for the seven hypothesis-related questions were structured as a Likert-like scale: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. The seven questions were aligned with the hypotheses (h) as follows:

- Question 7: h_1
- Question 9: h_2
- Question 10: h_3
- Question 12: h_4
- Question 15: h_5
- Question 16: h_6
- Question 17: h_7

The survey was field-tested on four individuals who were not included within the research sample. Three of the individuals in the field test were of the same characteristics as the research sample; the fourth was experienced in research design. These individuals were asked what issues they thought were being determined with each survey question. Survey questions that generated differences between the expected and actual responses were rewritten and reviewed by the testers.

PROCEDURES

There were six active-duty flying squadrons stationed at Randolph AFB: the 99 Flying Training Squadron (FTS), 558 FTS, 559 FTS, 560 FTS, 562 FTS and the 563 FTS. Each squadron's commander allowed surveys to be distributed in the squadron's internal mailboxes. The surveys were distributed to the squadrons in numerical order (99 FTS through 563 FTS).

The respondents were instructed to leave the completed survey in a manila envelope next to the mailboxes. The envelope was checked periodically for completed surveys. After two weeks, if no response had been received from a potential respondent, a follow-up letter and copy of the same survey were distributed to the non-responder's mailbox. No

surveys were accepted more than seven days after the follow-up was distributed. At that point, all of the manila envelopes were removed from the squadrons.

A control number was placed on each survey for tracking purposes. Once a subject responded, their name was annotated on the master list and the tracking number was removed from their survey. Therefore, any association between that person and their tracking number was removed. Once the tracking number was removed from the survey, even the investigator had no way of determining how a specific individual responded.

STATISTICAL ANALYSES

Hypotheses were tested with the Chi-Squared test. The 90% confidence level was used to determine two-tailed statistical significance. For Questions 7, 9, 10, 12, 13, 15, 16, and 17, the Likert-like scaling in the survey was degraded from ordinal to nominal scaling: the responses of Strongly Agree and Agree were combined into a “positive” category, the responses of Disagree and Strongly Disagree were combined into a “negative” category, and the neutral responses were discarded. Combining similar responses into a single category improved survey reliability in terms of the probability that a subject would answer the question in the same manner if they took the survey repeatedly. Discarding neutral responses removed a potential source of ambiguity from the interpretation of response distributions in contingency tables. The positive category became the first observed frequency (F_{O1}). The negative category became the second observed frequency (F_{O2}). For the Chi-Square analyses, the first and second expected frequencies (F_E) were one-half of the sum of the two F_O values.

RESULTS

Three hundred-ninety surveys were distributed to the pilots and navigators assigned to the six active duty flying squadrons of the 12th FTW on October 18, 2004. Two weeks later, on November 1, 2004, 125 surveys (32%) were collected from the aircrews who responded initially. Later that same day a follow-up letter and survey were distributed to those aircrews who had not yet responded. One week later 37 additional responses were received for a total of 162 responses (41.5%).

RESPONDENTS

The rank distribution for USAF pilots and navigators is shown in Table 1, and the aircraft type assignment breakdown for pilots is shown in Table 2 (Air Force Personnel Center, Randolph AFB, Texas, Statistics, November 2004). Due to the increased level of experience required to have a flying assignment in the 12th FTW, the bulk of the 162 respondents were Captains, followed by Majors and Lieutenant Colonels (Table 2). There were no responses from either Colonels or Generals, as they were not assigned to the individual flying squadrons. None of the Lieutenants had two or more years of operational experience prior to assignment to the 12th FTW; thus, they did not qualify for the research population. Thus, Captains were over-represented and Lieutenants were under-represented in the sample, as compared to the distribution of pilots and navigators in the population of interest.

Table 1. Rank structure for USAF pilots and navigators, and the research sample.

Rank	USAF Pilots	USAF Navigators	Research Sample
Lieutenant	15.7%	17.3%	0
Captain	35.7%	24.3%	46.3%
Major	24.9%	26.2%	29.6%
Lt Colonel	16.8%	24.5%	24.1%
Colonel	5.7%	6.8%	0
General	1.1%	0.1%	0

Table 2. Aircraft type breakdown for USAF pilots and navigators, and the research sample.

Aircraft Type	USAF Pilots	USAF Navigators	Research Sample
Fighter	26.6%	14.3%	19.1%
Airlift	28.9%	30.9%	34.0%
Tanker	17.8%	25.8%	9.3%
Helicopter	5.4%	0	3.1%
Bomber	7.8%	20.4%	12.9%
Instructor	2.9%		0
Other	10.5%	8.6%	21.6%

The majority of respondents flew airlift, followed by fighters, bombers, tankers, other, and helicopters. Tankers were under-represented in the sample.

The average age of the respondents was 36 years; the youngest was 27 years old and the oldest was 49 years old. There was a high proportion of the respondents who had logged more than 3,000 military flight hours. This spike was attributed to the higher experience required to be instructor pilots and navigators in the 12th FTW. The flight hours experience distribution of the respondents is shown in Figure 1.

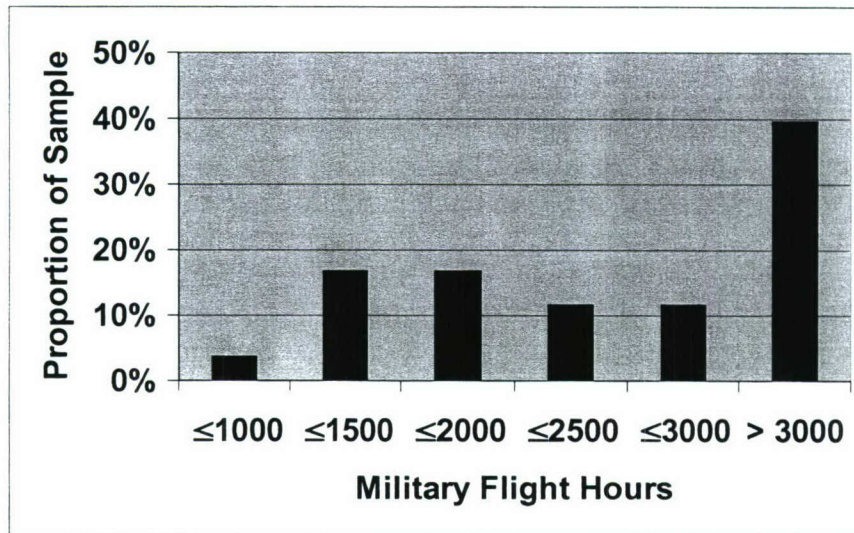


Figure 1. Military flight hours experience distribution of the respondents.

RESPONSES

The numbers and proportions of responses to the seven hypothesis-related questions are shown in Tables 3 and 4. The Chi-squared test results for hypotheses were derived from two-by-two contingency tables (positive or negative vs. observed or expected; df = 1) created from all non-neutral responses within the set of 162 responses.

Table 3. Numbers of responses to the seven hypothesis-related questions (n = 162).

	Q7	Q9	Q10	Q12	Q15	Q16	Q17
POSITIVE	106	153	106	139	44	65	108
NEUTRAL	3	4	20	13	55	41	20
NEGATIVE	53	5	36	10	63	56	34

Table 4. Proportions of responses to the seven hypothesis-related questions (n = 162).

	Q7	Q9	Q10	Q12	Q15	Q16	Q17
POSITIVE	65.4%	94.4%	65.4%	85.8%	27.2%	40.1%	66.7%
NEUTRAL	1.9%	2.5%	12.3%	8.0%	34.0%	25.3%	12.3%
NEGATIVE	32.7%	3.1%	22.2%	6.2%	38.9%	34.6%	21.0%

Hypothesis 1. Question 7 was related to hypothesis 1 (h_1). It stated: “I have experienced at least one episode of unintentional sleep while flying at my crew position.”

The positive-response majority provided statistically significant support for h_1 ($X^2 = 17.67$, $p < 0.001$).

Hypothesis 2. Question 9 was related to h_2 . It stated: “I have experienced at least one performance degrading effect of fatigue while flying at my crew position.” The positive-response majority provided statistically significant support for h_2 ($X^2 = 138.63$, $p < 0.001$).

Hypothesis 3. Question 10 was related to h_3 . It stated: “I feel that poor flight scheduling (for example: show times, frequency of flights, flight times more than six circadian hours different than recently scheduled) was the primary source of my in-flight fatigue.” The positive-response majority provided statistically significant support for h_3 ($X^2 = 34.51$, $p < 0.001$).

Hypothesis 4. Question 12 was related to h_4 . It stated: “I have received sufficient training and education on the many different countermeasures that combat fatigue.” The positive-response majority provided a statistically-significant rejection of the negatively-cast h_4 ($X^2 = 111.68$, $p < 0.001$).

Hypothesis 5. Question 15 was related to h_5 . It stated: “I feel that I would benefit from taking prescribed amphetamines (Go Pills, such as Dexedrine®) to stay awake in flight during an operational mission.” The responses provided a moderately-significant rejection of h_5 ($X^2 = 3.37$, $p < 0.10$). However, among the 25 aircrew members who had actually used Go Pills to combat fatigue, positive responses (17) outnumbered negative responses (8) by a ratio of more than 2:1.

Hypothesis 6. Question 16 was related to h_6 . It stated: “I feel that I would benefit from taking prescribed sleeping pills (No-Go Pills, such as Restoril® or Ambien®) to aid in falling asleep in preparation for or to recover from an operational mission.” The responses failed to support or reject h_6 ($X^2 = 0.67$, $p > 0.10$). However, among the 45 aircrew members who had actually used No-Go Pills for sleep to combat fatigue, there were 32 positive responses, 7 negative responses and 6 neutral responses.

Hypothesis 7. Question 17 was related to h_7 . It stated, “The conditions of my sleeping quarters (deployed, TDY or at home) contributed to at least one of my incidents of in-flight fatigue.” The positive-response majority provided statistically significant support for h_7 ($X^2 = 38.56$, $p < 0.001$).

Effects of Fatigue. Most of the aircrew members responded to Question 8 that they had experienced degraded situational awareness (73%) and slowed reaction time (67%) due to fatigue while flying (Figure 2). Over 43% reported that their fatigue had caused an increase in distractibility and procedural errors, while many had also experienced forgetfulness (41%) and apathy (33%). One-quarter of those surveyed indicated that they had used poor judgment as a result of fatigue and 3% stated that there were other performance degrading effects that they had experienced such as irritability, slowed speech and poor regulation of body temperature.

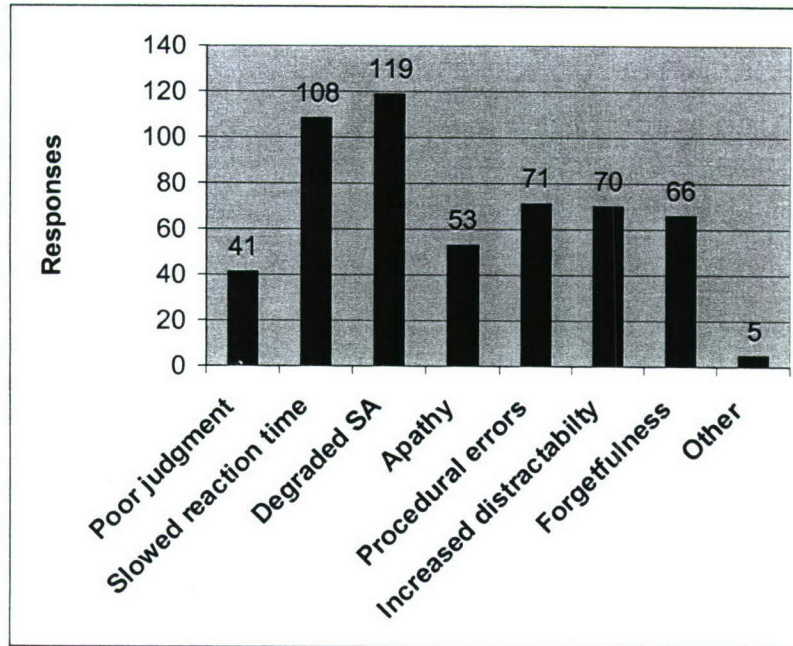


Figure 2. Reported performance degrading effects of fatigue experienced in flight (SA is situational awareness).

Causes of Fatigue. In response to Question 11, most (74%) of the respondents reported disruption of circadian rhythm as one of four main causes of the fatigue that they experienced in flight (Figure 3). Nearly one-third reported it as their number-one cause. Lack of sleep (68%), operations tempo (65%) and poor scheduling (29%) rounded out the top four causes.

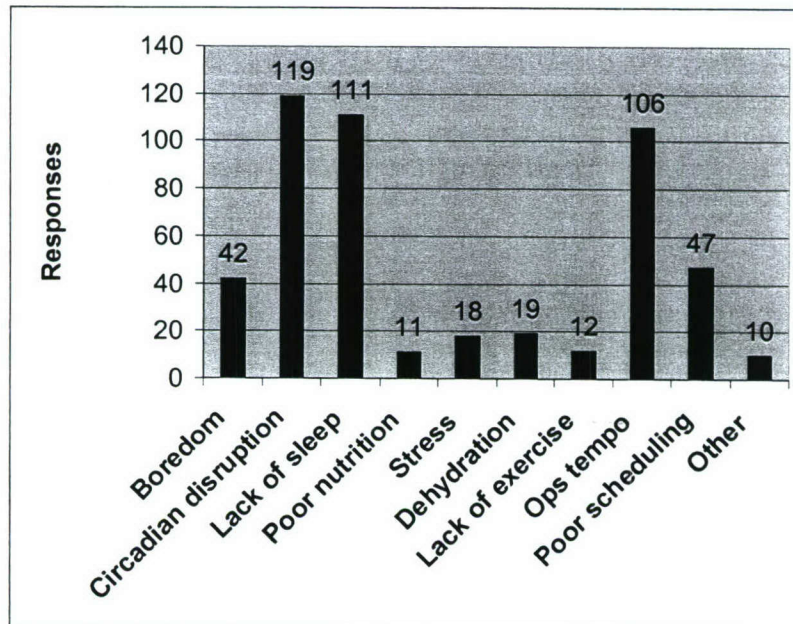


Figure 3. Reported causes of fatigue experienced in flight.

DISCUSSION

In summary, the data indicated that:

- Episodes of unintentional sleep may be common in cockpits throughout the USAF.
- Episodes of fatigue-induced performance degradation may be common in cockpits throughout the USAF.
- Degraded situational awareness and slowed reaction time due to fatigue had been experienced while flying.
- Disruption of the circadian rhythm was the greatest contributor to losing sleep and becoming fatigued.
- Improper mission scheduling may be the main cause for in-flight fatigue.
- Poor sleeping quarters contribute to in-flight fatigue.
- The aircrews had received sufficient training and education on the different countermeasures that combat fatigue, but still reported personal experiences of fatigue in the cockpit.
- There were overall biases against the use of Go and No-Go pills, but biases in favor of using them among those who had actually used them as fatigue countermeasures for missions.

The data suggested that episodes of unintentional sleep may be common in cockpits throughout the USAF. Nearly two-thirds of the respondents reported experiencing unintentional sleep while flying at their crew position. Unintentional sleep or "micronaps" are common among fatigued individuals and would be especially prevalent during the monotonous phases of long flights. One pilot recalled an experience he witnessed during a night sortie from Germany to his home base in the United States.

We had been on the ground in Germany for four days so that was the time zone our bodies were adjusted to. The sortie was not excessively long but our flight took-off at 10:00 pm German-time. We flew all night and arrived to our home station at sunrise. My co-pilot had several "micronaps" while we were being vectored to ILS [Instrument Landing System] final [in preparation for landing]. He was responsible for the radios, but missed several calls, causing the need for the controller to repeat himself several times.

Fatigue that leads to "micronaps" does not occur only during over-water night flights, but also among aircrews who fly short, local, day-time sorties. A training command pilot stated,

I was taking one or two masters [degree] classes (5 - 10 pm) each semester to stay competitive for promotion. My unintentional sleep experience occurred during an AETC assignment where the crew show-times were routinely at 0430 hours in the morning for a 12-hour duty day. In addition, I experienced micronaps when I flew bomber [type aircraft] operationally; flying 20-hour bomber missions without aircrew augmentation was extremely fatiguing.

The data also suggested that episodes of fatigue-induced performance degradation may be common in cockpits throughout the USAF. Nearly all of the respondents reported experiencing at least one performance-degrading effect of fatigue while flying at their crew position. Fatigue has become a national problem among the American workforce. "The National Sleep Foundation suggests that Americans have reduced their average amount of nightly sleep by 20% over the past century...in part because of widespread efforts to accomplish more with less" (Caldwell & Caldwell, 2003). The USAF has reduced its personnel strength sharply over the past 14 years, while the deployment operations tempo has increased sharply. It is safe to say that USAF aircrews have felt the effects of this drawdown and have needed to work more hours each week than before.

The majority of the aircrews surveyed indicated that they had experienced degraded situational awareness and slowed reaction time due to fatigue while flying. Nearly half reported that their fatigue had caused an increase in distractibility and procedural errors, while many had also experienced forgetfulness and apathy. One quarter of those surveyed indicated that they have used poor judgment as a result of fatigue.

A navigator who flew reconnaissance aircraft stated that a disruption of his circadian rhythm was the greatest contributor to him losing sleep and becoming fatigued. "I tended to toss and turn for hours and then go fly. After the initial rush of activity such as briefing, stepping and pre-flighting the aircraft, take-off, [aircraft] systems checks... then, I seemed to mentally and physically crash, especially when the environment was dead. Boredom contributed to my fatigue." Military aircrews cannot afford to make mistakes in the cockpit because they are fatigued. A procedural error, such as an incorrect switch actuation, or a lack of situational awareness experienced while flying over a combat zone could cause an unnecessary, catastrophic loss of lives and aircraft.

The data indicated that improper scheduling may be the main cause for in-flight fatigue. The principal investigator (PI) expected this result because she experienced many months of fatigue caused by poor flight scheduling while deployed to the Persian Gulf for Operation Iraqi Freedom. As a designated night flying aircrew, the PI needed to invert her circadian rhythm to accommodate night flying and day sleeping. Unfortunately, mission planners often scheduled the PI to fly a day consistent with her inverted circadian rhythm, but then scheduled her the following day to fly during her previous day's sleep cycle. Naturally, she was extremely fatigued during the sortie flown on the latter day. This type of scheduling continued throughout the PI's entire five-month deployment without any sense of consistency (see also Schultz and Miller, 2004).

Three-quarters of the respondents reported disruption of circadian rhythm as one of their top three causes of fatigue experienced in-flight, and nearly one-third reported it as their number one cause. Lack of sleep and operations tempo followed closely behind as one of the top three reported causes of in-flight fatigue. Poor scheduling has been shown to be the catalyst of in-flight fatigue because it causes disruption of circadian rhythm and lack of sleep.

A C-5 pilot recalled,

I can't count the number of times I have been alerted to fly at the exact time I would normally be going to bed. As hard as I try to get some sleep beforehand, it never works out. Most of the 11 pm alerts were for 24-hour augmented days of which we used about 23.5 hours.

A pilot who flew the C-130 in the Persian Gulf during Operation Enduring Freedom said (also, see Miller, 2005a):

The schedulers established night crews and day crews, which was a beneficial way to allow the crews to have a relatively predictable sleep pattern. But on my following two deployments, I recommended this to the schedulers who dismissed the idea as being impractical from a scheduling standpoint. A little positive reinforcement from the commander and some "can-do" attitude would have helped change their minds.

Air Mobility Command aircrews were scheduled on a rotating or stretched circadian rhythm cycle that had caused considerable problems with obtaining quality sleep even though the aircrews were exhausted. One pilot stated,

Airlift pilots have a 24-hour augmented duty day, where you are supposed to get a nap on the plane, but the quality of sleep is very low. The first flight of the mission tends not to be extremely fatiguing but it cumulatively adds up. We are already off of our normal sleep cycle on the first day, but then continue to operate on a different sleep cycle with each day of the mission. We operate on a schedule that is 20-24 hours awake, followed by 8 hours of sleep. This causes our circadian rhythm to be on a 28-32 hour cycle for several days in a row. I have flown this type of schedule for 200 days/year over the past six years.

The contribution of poor sleeping quarters to in-flight occurrences of fatigue had been indicated previously for F-16 crews flying in combat (Schultz and Miller, 2004). The survey results gathered here indicated that the problem of poor sleeping quarters generalizes to all USAF aircraft types and flight operations.

Scheduling problems that arise during operational missions are often acceptable in the short term. However, the military has often caused many of their aircrews to become extremely fatigued while at home "practicing" to be at war, which is less defensible. In fact it has the potential to be much more dangerous than certain aspects of combat because there are fewer distractions while deployed. For most military aircrews "playing war" at home, life goes on for the rest of the family and prevents the aircrew from attaining adequate sleep. In addition, this lack of sleep while at home may be much more dangerous because the fatigued aircrew actually need to drive themselves to and from work in rush-hour traffic, which is not often the case in a deployed location. The risks of motor vehicle or aircraft accidents are increased. A fighter pilot with over 3,000 hours of flying experience said,

The worst fatigue situation occurred during Wing Exercises at home base where we were simulating combat operations by flying two to three sorties at night and arriving home after sunrise. During the sortie the most fatiguing portion was

during the medium altitude drone to the entry point of the low level or military operating area at 2-3 am. It was also impossible to get to sleep at home during my family's breakfast time. I would never get a full eight hours of sleep due to all the distractions.

Operations tempo is less controllable from the standpoint of the number of sorties required to defend our nation, but the manner in which those sorties are filled with aircrews by the unit schedulers is very controllable. A C-5 pilot recalls, "I have been alerted 45 hours into our 48-hour alert window. We needed to take off within three to four hours of the phone call, to fly a 24-hour crew day. I have had this occur more than twice a week, which caused me to be extremely fatigued while flying the missions."

The USAF had recently incorporated fatigue countermeasures into the General Flight Rules Instruction¹. Despite the rules in the AFI, to our knowledge mission schedulers seldom plan for the use of fatigue countermeasures, placing their aircrews at unnecessary risk for a fatigue-related mishap. In addition, Air Force supervisors and schedulers seldom conduct fatigue risk assessment for mission schedules (for an approach to fatigue risk assessment, see Miller, 2005b).

The respondents felt they had received sufficient training and education on the different countermeasures that combat fatigue. However, they still reported personal experiences of fatigue in the cockpit. One pilot stated that exercise has been the most important countermeasure to help him "stay on track during [periods of] high operations tempo," but yet this pilot still responded that he had experienced at least one episode of unintentional sleep while flying. Logically, if exercise was his key to success to combat fatigue in the cockpit, then he should have not fallen asleep while flying his airplane. Possibly he retained only the one specific type of fatigue countermeasure (exercise) from his formal training, and then neglected to practice the other countermeasures taught in the class.

Though the aircrews received fatigue countermeasures training and perceived that they were sufficiently educated, it is possible that they did not retain the information. They reported significant problems with fatigue. In addition, there may have been other external stimuli that caused aircrews to ignore what they had learned. A bomber pilot responded, "Education is great but we are often forced to disregard what we have learned due to Ops Tempo." A C-5 pilot explained how the Air Mobility Command schedule breeds fatigue as a way of life:

AMC stresses Operational Risk Management to assess potential problems that could occur. The fact that we all recognize that we are tired from the start helps us because we can begin applying fatigue countermeasures early on. AMC said

¹ AFI 11-202V3 (6 June 2003). *General Flight Rules*. Headquarters Air Force, Washington, DC.

they wanted to give crews a more stable schedule to improve quality of life. Great concept but it is not the business AMC is in, when the end user says they need it here on X day at Y hour, our schedule is based on that regardless of the time of day or night. As you read this there are crews that are flying when you went to bed, and will still be flying as you wake up. We all have our "war stories" and our own way of coping with being tired and fatigued. Mine was coffee, snack food, talking to the other crewmembers and finally just pressing through.

A number of useful fatigue articles, pamphlets and books that were written for aircrew members and other non-scientists were located during the literature search and review conducted for this project (Melfi, 2005). These articles may serve as useful educational materials. They are listed here. Additionally, the web site of the National Sleep Foundation provides excellent educational materials (www.sleepfoundation.org).

- Pamphlets published by the Biobehavioral Performance Branch, Air Force Research Laboratory, Brooks City-Base, TX (www.brooks.af.mil/AFRL/HEP/HEPF/Brochures/)
 - *Asleep at the Throttle*
 - *Fighting Fatigue*
 - *Fly by Night*
- Articles published in *Flying Safety Magazine*, Air Force Safety Center, United States Air Force, Kirtland AFB NM (<http://afsafety.af.mil/magazine/htdocs/afsc2.htm>).
 - Caldwell J. Fatigue facts for aviators...and everybody else. October 2002.
 - Caldwell JL. Napping: power or poison? October 2002.
 - Caldwell J, Brown L. Runnin' on empty? "Go pills," fatigue and aviator safety. March 2003.
 - Levy RA. There are no new accidents. July 2001.
 - Shaver R. Mind over matter. July 2003.
- Articles published in *The Combat Edge*, Air Combat Command, United States Air Force, Langley AFB VA (http://www2.acc.af.mil/combat-edge/past_issues/allissues.htm).
 - Bonner A. Fighting the fatigue factor. July 2003. Provides some general guidelines on fatigue avoidance.
 - Hagginbotham DA. Combating fatigue. November 2002. Discusses fatigue issues in long-duration sorties.
 - Marshall JL. Plan for combat safety. February 2002. Describes cockpit napping during long-duration B-2 sorties.
 - Mlodzik M. Fatigue can cause mishaps. January 2001. Discusses aircraft maintainer fatigue.
 - Walter M. The fatigue factor. March 2000.
- Books and Report
 - Caldwell J, Caldwell JL. *Fatigue in Aviation*. Ashgate Publishing Company, Vermont, 2003.
 - Harvard Health Publications. *Boosting Your Energy*. Special report, 2002.

- Miller JC. *Controlling Pilot Error: Fatigue*. McGraw-Hill, New York, 2001.
- Other Useful Articles
 - Argenti D. Mastering your circadian rhythm: Sleep is vital to maintaining health and fitness on the night shift. *American Fitness*, January-February 2002.
 - Correll JT. Strung out: We have too few forces and too little money chasing too many open-ended deployments. *Air Force Magazine*, September 1998.
 - Rosekind MR, Gander PH, Miller DL, Gregory KB, McNally KL, Smith RM, Lebacqz JV. NASA Ames Fatigue Countermeasures Program. *FAA Aviation Safety Journal*, 3(1), 20-25, 1993. Discusses pilot fatigue, sleep, and circadian rhythms.

Many respondents felt that they would not benefit from medication stimulants (Go Pills) to aid in wakefulness during flight to help combat the effects of fatigue during an operational mission. There are several logical reasons why the aircrews responded in this manner. The majority of the respondents had never used Go Pills and, therefore, had not received the education and training on the safety of this type of medication and its potential side effects. They may have feared that dependency or addiction to the medication would occur. In addition, "there has never been an Air Force aviation mishap in which dextroamphetamine [Dexedrine] was found to be a contributing factor whereas untreated fatigue has been at least partially responsible for numerous accidents" (Caldwell & Caldwell, 2003). When it comes to prescription medication, ignorance was not bliss for these aircrews. The majority of those respondents with personal experience with Go Pills appeared to understand how beneficial the Go Pill has been for military operations over the past 60 years.

[The Go Pill] Dexedrine was given to F-15C pilots flying lengthy combat air patrol missions during Operation Desert Storm, and it was found that the stimulant enabled flight crews to overcome fatigue from sleep deprivation and circadian disruptions. No adverse effects were reported, and no aviators expressed a need to continue the drug once proper work/sleep schedules were reinstated (Caldwell & Caldwell, 2003). (Also, see Schultz and Miller, 2004.)

An AMC pilot who flew the C-17 believed that some aircrews may have answered the question negatively in hopes of not having their duty day lengthened in the future. "Some AMC aircrew may be concerned about TACC [Tanker Airlift Control Center] mandating the use of Go Pills to extend the aircrews' already long day. I feel the availability of the Go Pills being offered as an option may help certain aircrews, as long as they are only being used at the discretion of the aircrew member."

One response from a highly experienced fighter pilot was quite troubling; he may have been an accident waiting to happen: "I prefer the degradation of performance rather than to deal with the consequences of taking such pills. I have only flown long eight to nine hour sorties during benign ocean crossing missions, not during war though." While

another pilot mentioned that the combination of adrenaline and a quart of black coffee helped him combat fatigue rather than using Go Pills.

There was a significant difference between pilots and navigators in the amount of disagreement with the usefulness of Go Pills. Even though both the pilots and the navigators disagreed, the navigators disagreed at a significantly higher rate than the pilots. The lesser degree of disagreement among the pilots may have been due to the fact that pilots are directly responsible for the safety of the aircraft and its inhabitants. Even a small amount of fatigue will hinder an aircraft commander's judgment and decision-making ability, as well as his or her ability to actually fly and land the aircraft in a safe manner. With the exception of the navigator rated officers known as Weapon System Officers (WSOs), who fly the fighter-bomber mission, and navigators responsible for airdrop missions, the role of the navigator is typically that of a support role. Fatigue experienced by the traditional navigator is not as time critical as it would be if experienced by the pilot who was actually flying. For this reason a pilot may feel more compelled than a navigator to use a Go Pill to maintain alertness.

The Principal Investigator used Go Pills during Operation Iraqi Freedom during a few of her night sorties and felt that the effects were extremely beneficial. When authorized, she elected to always carry Go Pills with her in the jet during night sorties in the event that she might become fatigued. On one sortie in particular, she took off at 9 pm to fly deep into the heart of Iraq for a Close Air Support mission in support of the Marines. The sortie was only scheduled to be seven hours in duration. At 3 am, when she would have been starting her return to base, multiple hostilities increased on the ground and the sortie was extended two hours longer than planned. Already beginning to feel fatigued, due to her body being in the circadian trough at 3 am and with three more hours until landing, she elected to take a Go Pill to maintain alertness.

In the event aircrews become fatigued in the aircraft, having Go Pills as an option is an overwhelming source of comfort. Another fighter pilot responded, "During one flight the Air Force saved over \$180 million in resources by allowing me to use Go Pills."

There were approximately equal numbers of respondents who perceived benefits and no benefits to be gained from taking No-Go Pills. The respondents who felt that No-Go Pills were beneficial in aiding them to fall asleep in preparation for, or to recover from, an operational mission were very pleased with their results when they had used the No-Go medication. The PI had many positive experiences using zolpidem (Ambien®) while deployed for the war. Most of her night missions would allow her to get back to her tent just prior to seeing the sun rise above the horizon, but there were several missions that were extended, causing her to land well after the sun was up. Seeing the sun would disrupt her circadian rhythm, which made it extremely difficult to fall asleep. After many experiences of trying to fight her wakefulness, by lying in the bed for an hour unable to fall asleep, she decided to use zolpidem. The zolpidem worked very well: 20 minutes after taking the No-Go pill, she would fall asleep and sleep restfully for the following eight hours. The other scenario that proved the No-Go Pills to be helpful for the PI was when the squadron schedulers would shift her off of her normal circadian schedule

without notice. In these instances, she needed to take a nap to adjust her body to a new circadian rhythm to remain alert while flying and fighting. The No-Go Pills would assist her in falling asleep for her nap only three hours after waking up from eight hours of restful sleep.

The sun can be a friend or an enemy. Seeing the sun first thing in the morning may help aircrew to feel more alert: a pilot who flew in Air Mobility Command responded, "I find that I feel extremely tired 30 minutes prior to sunrise, but as soon as the sun is up, I catch my second wind." The sun had temporarily cured this pilot's fatigue problem while he was airborne, at least in terms of his subjective perception (perhaps not in terms of his mental performance). However, if he had been attempting to maintain a night schedule, the sunrise probably caused circadian disruption, making it much more difficult for him to fall asleep a couple of hours after the landing. Another AMC pilot stated, "Airlift pilots are not authorized to take uppers and downers. The best I have been able to do is occasionally cheat by taking Tylenol PM."

AMC began recently to offer No-Go Pills to their aircrews, but had required them to fly inconsistent schedules for decades prior. Some aircrews have chosen to misuse alcohol as a sedative to assist them in falling asleep. According to the regulations, alcohol is authorized as long as it is not being consumed within 12 hours of flight-time. The problem with using alcohol as a sleep-aid is that it tends to cause sleep maintenance insomnia. In turn, this will cause the aircrew member to wake up unrefreshed and groggy. Self-medicating or misusing alcoholic beverages as a sedative are not intelligent options to help aircrews sleep in preparation for flying.

The aircrews who felt that No-Go Pills would not be beneficial may have responded so because they were uneducated about this useful fatigue countermeasure and afraid of the potential side effects or the possibility of becoming addicted to the medication. Others may have felt as though medicating is like putting a band-aid on the problem instead of fixing the root cause of why the medication is needed.

There was a significant difference in the way aircrews responded concerning the benefits of using No-Go Pills based upon whether they had actually used No-Go Pills to assist them in falling asleep to combat fatigue. Those who had experience using No-Go Pills felt they would benefit from sleeping pills (No-Go Pills) to assist them in adjusting their circadian rhythm, to help combat the effects of fatigue in preparation for or to recover from an operational mission.

Sleeping medication has become acceptable recently in American culture due to the many television advertisements trying to provide sleeping assistance to much of the population. As a result, many aircrews who were offered No-Go pills were willing to give them a chance. Those aircrews who had actually used No-Go Pills could not say enough about the important benefits the medication provided for them. A C-130 pilot responded,

I used Ambien on two deployments when we arrived in theatre, as well as when scheduling required a change in sleep cycle. The Ambien was great; I woke up feeling alert and rested. During long missions [12 to 16 hours] though, it was still

helpful to take a short nap at the six-hour point in the sortie in order to make it the remaining six to ten hours.

No-Go Pills have provided USAF aircrews with the opportunities to have full and restful sleep so they can fly their aircraft with less fear of becoming fatigued due to irregular work-rest schedules.

ASSUMPTIONS AND POTENTIAL LIMITATIONS

We assumed that:

- The aircrews surveyed were representative of the USAF's operational community. Because Randolph Air Force Base (AFB) was the home of Joint Specialized Undergraduate Navigator Training (JSUNT) and Pilot Instructor Training (PIT), the aircrew who were surveyed had in fact come from all of the major weapon systems throughout the USAF.
- The aircrews surveyed had a general and equal knowledge of fatigue and its effects.
- The aircrews did not fly fatigued intentionally.
- Those responding to the survey had the same general opinions in the same proportions as those who elected not to respond.
- The surveys were answered truthfully.

There were at least three potentially serious limitations of the investigative method: maturation, history and differential selection of participants. According to Gay and Airasian, maturation "refers to natural physical, intellectual, and emotional changes that occur in participants over a period of time" (2003). The topic of fatigue in the aviation industry had recently become well-known due to the increasing number of aircraft accidents identified as caused by aircrew fatigue. This increasing safety concern may have caused the individual squadrons to educate their aircrews on fatigue countermeasures during this study. In addition the respondents may have reported on fatigue issues that they repeatedly heard about from instructors and fellow aircrew members in the unit; for example, feeling more tired in the afternoon or needing caffeine to feel more alert. The best way to overcome this potential limitation was to minimize the time between distributing and collecting the surveys.

History is "something that changes during the time the data collection is taking place" (B. Rothwell, personal communication, 2004). For example, the participant's survey answers could have been altered if the 12th FTW switched from flying during the daytime to a night flying schedule, due to the increase in aircrew fatigue associated with night operations (this did not happen).

Finally, differential selection of participants "usually occurs when already formed groups are compared, thereby raising the threat that the groups were different before the study even begins" (Gay and Airasian, 2003). This limitation was controlled by basing the primary conclusions of the investigation upon combined data collected across several previously-formed groups (the squadrons).

CONCLUSIONS

The purpose of this investigation was to determine whether USAF aircrews experienced fatigue in flight, whether they had been sufficiently educated about the causes and effects of fatigue in flight operations, and what their views were of the proactive countermeasures to fatigue that can enhance alertness while airborne. The investigation also examined their perceptions of flight scheduling and operations tempo pertaining to fatigue and their views on what actually causes the fatigue they may experience in flight.

The respondents:

- Reported performance-degrading effects of fatigue in the cockpit that were specifically identified as limiting factors. About 70% reported degraded situational awareness and slowed reaction time in their aircraft due to fatigue. In addition, almost all had lived through a flight where they had fallen asleep unintentionally while flying. In fact, only 3% reported that they had never fallen asleep in flight.
- Perceived that they had received sufficient training on the many different countermeasures to combat fatigue while flying. However, these same pilots and navigators had unintentionally fallen asleep in the cockpit, causing the need to have a crewmate wake them up in some cases. These aircrews had accepted these events as the norm and had learned to live with in-flight fatigue. Although aircrews received fatigue training, it may not have been comprehensive enough and/or may have been retained enough to reduce their in-flight fatigue.
- Felt that poor flight scheduling was the primary source of their in-flight fatigue. Many aircrews were continuously scheduled to fly at times that were at odds with their circadian rhythm, never allowing them to get proper rest to prepare for flight. If scheduled to have an adequate amount of time to adjust their circadian rhythm, and given adequate sleeping quarters, aircrews would be able to sleep in a more rested and restorative manner which, in turn, would allow them to be more alert and effective while flying, regardless of the time of day or night.
- Although the majority of those surveyed did not feel that Go or No-Go Pills would benefit them, those who had used the medications were adamant about the positive beneficial effects they experienced. In many of these cases, the aircrew reported that increased operations tempo did in fact contribute to their in-flight fatigue and the option of taking a Go Pill increased their alertness so that they could fly their aircraft safely.

RECOMMENDATIONS

The Air Force should conduct mandatory annual fatigue training based upon current fatigue research. All aircrews should be taught the causes and effects of fatigue and fatigue countermeasures, and should discuss accident avoidance by reviewing previous accidents that were caused by fatigue. Training a Flight Surgeon or Wing Safety Officer who, in turn, will train the aircrews of each individual unit, would be invaluable. The fatigue training should be accountable and tracked electronically in the same way that all other annual training is managed. Aircrews who do not receive refresher fatigue training within 365 days should be grounded from flying until their training is complete. The annual fatigue training should teach aircrews how to manage fatigue reduction through adequate sleep hygiene, diet and exercise, and also through the use of timely work breaks and exposure to light. It should be the individual aircrew's responsibility to practice intelligently the methods learned in their fatigue training throughout their daily life so they will be able to fly rested and alert. It should be management's responsibility to provide adequate sleeping quarters for deployed aircrews.

Flight operations should be scheduled to minimize the impact on aircrews' circadian rhythm. Air Force policy should be changed so that when scheduling aircrews for missions where the takeoff time is departing more than six hours different than the aircrews' circadian rhythm, additional time-off is allotted to allow the aircrews to adjust to the new schedule. The Fatigue Avoidance Scheduling Tool should be implemented in each and every flying squadron immediately. When the aircrews first arrive to work for the duty period, they should input the times of their previous rest cycle into FAST. This information should be automatically linked directly to the computers belonging to the squadron schedulers and supervisor on duty. When the aircrew's percentage of effectiveness is projected to fall below 90% the system should send a warning alarm of potential fatigue that may be present when that aircrew is scheduled to fly. With this information the duty scheduler and supervisor should replace the fatigued aircrew with a spare aircrew in order to ensure safety of flight within the squadron's flying schedule.

Finally, when the operations tempo does not allow the squadron schedulers to give their pilots and navigators sufficient time-off to adjust their circadian rhythm, medication should be offered to the aircrews. Medication should only be used in the event that the mission is essential and rest or alertness cannot be achieved naturally. No-Go Pills should be offered to aircrews that may have trouble getting adequate sleep due to readjustment of their circadian rhythm. Go Pills should be offered to aircrews as an option, to be carried with them while flying, in the event that they should become fatigued and are unable to step away from their crew position to take a nap. In either case, the medication should continue to be a highly controlled substance managed by the flight surgeon, to ensure that abuse does not occur. Having the medication available to aircrews, as an emergency back up, is much safer than allowing aircrews to continue to fly fatigued which could potentially lead to an accident.

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APPENDIX: SURVEY

1. Rank: 2Lt / 1Lt / Capt / Maj / Lt Col / Col
2. Aircraft currently flying: T-1 / T-6 / T-37 / T-38 / T-43 /
Other: _____
3. All Major Weapons Systems (MWS) previously flown:

4. Did you have **two or more years** of operational experience in your MWS prior to assignment to Randolph? Yes / No

If you answered "N/A" for question 3 or "No" to question 4 your portion of the survey is complete, please turn it in at this time.

5. Approximate military flight hours: < 1000 / 1000-1500 / 1501-2000 / 2001-2500 /
2501-3000 / > 3000
6. What is your age? _____

When answering the following questions, please reflect back on your Operational flying assignments.

Please circle one of the following responses where applicable:

SA=strongly agree, A=agree, N=neutral, D=disagree, SD=strongly disagree

7. I have experienced at least one episode of unintentional sleep while flying at my crew position. SA...A...N...D...SD
8. Please circle any and all performance degrading effects of fatigue you have experienced in flight:
Poor judgment / Slowed reaction times / Degraded situational awareness/
Apathy / Procedural errors / Increased distractibility /
Forgetfulness / Other:
9. I have experienced at least one performance degrading effect of fatigue while flying at my crew position.
SA...A...N...D...SD
10. I feel that poor flight scheduling (for example: show times, frequency of flights, flight times more than 6 circadian hours different than recently scheduled) was the primary source of my in-flight fatigue SA...A...N...D...SD

11. Please sequence the top three causes of fatigue you have experienced in flight by annotating a one, two, and three below:

Boredom	_____	Dehydration	_____
Disruption of circadian rhythm	_____	Lack of exercise	_____
Lack of sleep	_____	Operations tempo	_____
Poor nutrition	_____	Poor scheduling	_____
Stress	_____	Other	_____

12. I have received sufficient training and education on the many different countermeasures that combat fatigue
SA...A...N...D...SD
13. Have you ever taken prescribed amphetamines (Go Pills, such as Dexedrine) to stay awake in flight during an operational mission? Yes / No
14. Have you ever taken prescribed sleeping pills (No-Go Pills, such as Restoril or Ambien) to aid in falling asleep in preparation for or to recover from an operational mission? Yes / No
15. I feel that I would benefit from taking prescribed amphetamines (Go Pills, such as Dexedrine) to stay awake in flight during an operational mission SA...A...N...D...SD
16. I feel that I would benefit from taking prescribed sleeping pills (No-Go Pills, such as Restoril or Ambien) to aid in getting to sleep to adjust my circadian rhythm SA...A...N...D...SD
17. The conditions of my sleeping quarters (deployed, TDY or at home) contributed to at least one of my incidents of in-flight fatigue SA...A...N...D...SD

Any additional comments would be greatly appreciated. Please indicate which survey question you are commenting on and write your remarks on the back of the survey.